Use of arm and lesser saphenous vein compared with prosthetic grafts for infrapopliteal arterial bypass: Are they worth the effort?

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Purpose: **Arm and lesser saphenous veins (ALSVs) are generally considered to be the best alternative for infrapopliteal arterial bypass grafts when greater saphenous vein is not available. The need for additional incisions and repositioning of the patient, along with occasional use of general anesthesia for arm vein harvesting, led to our perception that the use of ALSVs increased operative time and possibly patient discomfort. Therefore, we compared the outcome of ALSVs with that of prosthetic infrapopliteal arterial bypass procedures performed at our hospital.**
Methods: **Between July 1, 1991, and Dec. 31, 1996, we performed 96 infrapopliteal arterial bypass procedures using 45 ALSVs (28 arm vein, 17 lesser saphenous) and 51 polytetrafluoroethylene (PTFE) grafts. Seventy grafts were single-length ALSV or PTFE bypass grafts, and 26 grafts were placed as the distal segment of a sequential or composite bypass graft. Every attempt was made to use ALSV and avoid the use of PTFE, even if a short segment of the vein graft measured less than 4.0 mm in diameter. There were no significant differences between patients with ALSV compared with PTFE grafts in terms of age, sex, indication for surgery, or number of previous revascularization procedures (2.1 vs 1.7), respectively ($p > 0.05$). However, ALSV grafts had more factors associated with an expected worse outcome: they were more commonly anastomosed to pedal arteries (17% [8 of 45] vs 0%; $p = 0.0009$), less commonly single-segment grafts (62% [28 of 45] vs 82% [42 of 51]; $p = 0.03$), had higher average runoff resistance values (2.3 vs 1.5; $p = 0.001$), and were less frequently treated with lifelong warfarin (65% [29 of 45] vs 95% [48 of 51]; $p = 0.0001$).**
Results: **The hospital mortality rate was 3.1% (3 of 96; 3 PTFE). All deaths were cardiac-related. Despite the potential factors associated with worse patency rates for ALSVs, 2-year assisted primary patency rates tended to be higher for arm veins (46%) than for lesser saphenous veins (23%) and PTFE grafts (26%), although this difference was not statistically significant. Limb salvage rates were similar between ALSV and PTFE grafts (76% vs 71%, respectively). The average operative time was significantly longer for ALSV bypass procedures (mean, 6.2 hours) than for PTFE bypass procedures (mean, 4.9 hours; $p = 0.003$), and for single-length conduits when revision of previously placed grafts was not attempted, the operative time was 4.0 hours for ALSV grafts and 2.5 hours for PTFE grafts.**
Conclusion: **In our experience ALSV bypass grafts to infrapopliteal arteries do not function as well as reported by some others. In spite of the extra effort involved, arm vein grafts are preferred over PTFE grafts for their likely higher assisted primary patency rates and equivalent, if not better, limb salvage rates. (J Vasc Surg 1997;26:919-27.)**

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Greater saphenous vein (GSV) has been shown to be the best conduit for infrapopliteal arterial bypass grafts.[1] In our experience, this vein is frequently not available or usable as a result of previous peripheral or coronary artery bypass procedures, previous vein stripping for varicose veins, or inadequate size or quality. Prosthetic grafts to infrapopliteal arteries yield poor long-term patency rates, although long-term anticoagulation therapy may improve these re-

Table I. Vein graft diameter in 45 ALSV infrapopliteal arterial grafts

Diameter	*No. of grafts (%)*
3.0 to 3.4 mm	4 (9)
3.5 to 3.9 mm	10 (22)
≥4.0 mm	31 (69)

sults.[1,2] Other autologous grafts, namely arm and lesser saphenous vein (ALSV), have been reported to yield acceptable long-term patency rates by some groups.[3-8] The use of ALSV involves additional incisions, possible repositioning of the patient when lesser saphenous vein (LSV) is harvested, and use of general anesthesia in most patients when long segments of arm vein are required. In addition, other groups have shown significantly inferior results of arm vein grafts compared with GSV grafts.[9] It was our perception that harvesting ALSVs was also associated with increased operative time and patient discomfort. The purpose of this report was to compare ALSV and prosthetic grafts for infrapopliteal arterial bypass procedures and to determine whether the use of ALSV was worth the extra effort to perform these challenging operations.

PATIENTS AND METHODS

Between July 1, 1991, and December 31, 1996, we performed 96 infrapopliteal arterial bypass procedures in 72 patients using 45 ALSV and 51 prosthetic (polytetrafluoroethylene [PTFE]) grafts at Pennsylvania Hospital in Philadelphia. During this same period we performed 170 infrapopliteal bypass procedures using single-length GSV (not including sequential or composite grafts). The indication for surgery was limb salvage in all of these cases.

Veins were routinely mapped before operation for all electives cases using duplex ultrasound (DU; Advanced Technology Laboratories, Ultramark HDI, Bothell, Wash.) for location, quality, and size in an accredited vascular laboratory. If both GSVs were less than 3 mm in diameter based on DU assessment or had been previously excised, ALSVs were then examined with DU before operation. Arm veins were routinely examined after tourniquet application, and LSVs were examined using a tourniquet if they were less than 3 mm in diameter when measured with the leg in the dependent position. To confirm that an apparently small-diameter GSV was unusable, during surgery the vein was gently distended with heparinized saline solution through a side-branch to determine whether it dilated to an acceptable diameter (≥3.5 mm). If not, the best ectopic vein identified by DU was used. Every attempt was made to use veins greater than 3.5 mm in diameter, measured after arterial inflow was established or after distention with heparinized saline solution, although if only a short segment was 3.0 to 3.4 mm in diameter the vein was occasionally used to avoid using a prosthetic graft (Table I). If arm vein or LSV was not adequate or available (43 cases) or if the patient was considered to be at high risk and unable to tolerate the additional operative time to harvest these veins (8 cases), a prosthetic graft was used (51 total cases). Seventy bypass grafts (73%) were single-segment grafts, and the other 26 bypass grafts (27%) were placed as the distal portion of a sequential or composite bypass graft (original proximal graft being GSV or PTFE; Table II).

ALSV bypass grafts included 22 cephalic vein, 17 lesser saphenous vein, four composite arm vein, and two basilic vein grafts. Twenty-nine grafts were reversed because they were equal diameter proximally and distally, and 16 were translocated because there

Table II. Comparison of risk factors for patients with ALSV (45) vs prosthetic (51)

Risk factor	*ALSV*	*PTFE*	*p*
Mean age (yr)	69 (47–91)	72 (45–97)	0.18
Males	23 (63%)	29 (57%)	0.53
Diabetes mellitus	25 (55%)	23 (46%)	0.43
Chronic renal failure (dialysis)	4 (7%)	8 (16%)	0.15
Indication for surgery			
Rest pain	18 (39%)	27 (52%)	0.20
Ulcer	9 (21%)	9 (17%)	0.56
Gangrene	18 (40%)	16 (31%)	0.39
Previous revascularizations (range)	2.1 (0 to 5)	1.7 (0 to 6)	0.26
Single-segment conduits	28 (62%)	42 (82%)	0.03
Proximal graft: GSV	5 (11%)	3 (6%)	0.36
Proximal graft: PTFE	8 (18%)	6 (12%)	0.40
Composite arm vein conduits	4 (9%)	0 (0%)	0.03
"Pure" vein or PTFE graft*	37 (82%)	48 (94%)	0.07
Distal anastomosis			
Anterior tibial	14 (32%)	15 (29%)	0.72
Peroneal	18 (39%)	18 (35%)	0.62
Posterior tibial	5 (11%)	18 (36%)	0.003
Pedal artery	8 (17%)	0 (0%)	0.0009
Adjunctive arteriovenous fistula	0 (0%)	22 (43%)	<0.0001
Lifelong warfarin after surgery	29 (65%)	48 (95%)	0.0001
Elective	43 (96%)	42 (83%)	0.04
Runoff resistance value (range)	2.3 (1.0 to 4.0)	1.5 (1.0 to 4.0)	0.001
Operative time (hr)	6.2 (3.5 to 10)	4.9 (2 to 8)	0.003

*"Pure," single-segment, composite or sequential grafts of one type of conduit: vein (including greater saphenous vein, LSV, or arm vein) or PTFE only.

was a size discrepancy. Translocated vein bypass procedures were performed using a 2.8 mm diameter angioscope (Olympus, Melville, N.Y.) to ensure complete valve lysis. Angioscopy was also liberally performed to assess the quality of the lumen of reversed arm veins because of the high incidence of luminal defects from previous venipunctures.[10] Although the LSV can be harvested with the patient in a supine position through a medial subfascial approach or through a separate posterior calf incision, we found that exposure of the vein was better with the patient in the prone position.[5] After LSV harvesting, the patient was turned to a supine position and reprepared and draped for the performance of the arterial bypass procedure. LSVs were generally reversed for bypass grafts.

Twenty-two PTFE bypass grafts (43%) had adjunctive distal anastomotic arteriovenous fistulas, seven (14%) had vein patches or cuffs at the distal anastomosis, and the remaining 22 (43%) were sutured directly to the artery.[11-13] Although there was no definite standardized approach, adjunctive fistulas were generally placed when an adequate-diameter tibial vein was present for construction of a fistula and when the surgeon believed that a particularly poor runoff artery was present. Ringed prosthetic grafts were used for all bypass grafts that crossed a joint.

Completion intraoperative arteriograms were obtained for all bypass procedures. More recently, completion DU was used for ALSV bypass procedures when appropriate equipment and technicians were available.

There were no significant differences between patients with ALSV or PTFE grafts in terms of age, sex, diabetes mellitus, renal failure, indication for surgery (rest pain, ischemic ulcer, gangrene), previous ipsilateral revascularizations, "pure" conduits composed of only vein or only prosthetic, or use of ALSV or PTFE as the distal segment of a sequential bypass (Table II). However, ALSV grafts were more commonly anastomosed to pedal arteries, less frequently maintained on lifelong anticoagulation therapy, less commonly single-segment bypass grafts, and had higher average resistance runoff values based on the SVS/ISCVS Ad Hoc Committee on Reporting Standards criteria compared with PTFE grafts (Table II).[14] Although not proved by randomized trials, all four of these factors would probably put ALSV grafts at more of a disadvantage than PTFE grafts in this series.

Patient information was prospectively entered into a computerized registry data base at the time of surgery (Microsoft Access). Graft patency for all ALSV and prosthetic bypass grafts was assessed using clinical evaluation and a graft surveillance protocol, which included DU, segmental pressures, and pulse volume recordings, performed every 3 months during the first 2 years after surgery and every 6 months thereafter.[15,16] Clinical findings that suggested a failing graft were return of preoperative signs and symptoms of arterial insufficiency such as rest pain, a new ulcer, or diminished pulses. Decrease in the ankle-brachial index more than 0.20 or amplitude of ankle or transmetatarsal pulse volume recordings more than 50% were other criteria that suggested a failing graft. Duplex criteria of a failing vein or prosthetic graft included peak systolic velocities less than 45 cm/sec throughout the graft, a peak systolic velocity greater than 300 cm/sec at a specific site in the graft or anastomosis, or adjacent peak systolic velocity ratio greater than 3.0.[15] Patency rates were calculated using life table analysis as suggested by the SVS/ISCVS Ad Hoc Committee on Reporting Standards.[14] Differences in patency rates were calculated using the log-rank test. For categoric variables, the significance of any differences between groups was analyzed by the χ^2 test or by Fischer's exact test when appropriate. A result was considered statistically significant with a p value less than 0.05, and only patency rates with standard errors less than 10% were considered statistically relevant. A threatened limb was considered successfully salvaged if a major amputation was not required, even if a new bypass graft other than the original ALSV or PTFE graft proved necessary.

RESULTS

The hospital mortality rate per bypass procedure was 3.1% (three deaths, 96 bypass grafts, 72 patients). Deaths were due to cardiac events and occurred in patients with PTFE bypass grafts who were believed to be at prohibitive risk to undergo ALSV harvesting.

There was no significant difference in 2-year assisted primary patency rates (32.7% vs 25.6%; $p = 0.82$) or secondary patency rates (46.1% vs 54.5%; $p = 0.17$) between ALSV and PTFE grafts, respectively, based on life-table analysis (Table III). There was no significant difference in overall limb salvage between the two groups (76% vs 71%; $p = 0.59$). Arm veins tended to have higher assisted 2-year primary patency rates than LSV and PTFE grafts (46.0% vs 23.5% vs 25.6%), but the difference was not statistically significant, nor did we find any significant differences in 2-year patency rates between PTFE grafts with and without adjunctive fistulas or be-

Table III. Cumulative 2-year patency rates of ALSV (45) vs. prosthetic (51) bypasses to infrapopliteal arteries

	Total	*"Pure" grafts*	*Single-segment grafts*
Primary patency			
ALSV	19.0 ± 6.5% (45)	31.3 ± 8.9% (37)	27.8 ± 9.9% (28)
Arm vein	29.8 ± 11.5% (28)	20.0 ± 10.3% (24)	36.0 ± 14.4% (18)
LSV	17.7 ± 9.3% (17)	15.0 ± 9.8% (13)	10.0 ± 9.5% (10)
PTFE	16.7 ± 6.8% (51)	21.0 ± 8.2% (48)	21.0 ± 8.2% (42)
Assisted patency			
ALSV	32.7 ± 7.5% (45)	34.5 ± 9.0% (37)	33.1 ± 10.2% (28)
Arm vein	46.0 ± 10.8% (28)	45.0 ± 14.9% (24)	55.0 ± 18.4% (18)
LSV	23.5 ± 10.3% (17)	15.0 ± 9.8% (13)	10.0 ± 9.5% (10)
PTFE	25.6 ± 7.4% (51)	28.4 ± 7.9% (48)	31.6 ± 8.7% (42)
Secondary patency			
ALSV	46.1 ± 8.1% (45)	44.7 ± 9.2% (37)	49.1 ± 10.9% (28)
Arm vein	55.3 ± 10.6% (28)	60.0 ± 15.5% (24)	64.0 ± 17.2% (18)
LSV	34.3 ± 11.2% (17)	29.0 ± 14.1% (13)	27.0 ± 16.3% (10)
PTFE	54.5 ± 8.7% (51)	58.9 ± 8.5% (48)	61.8 ± 8.9% (42)

Number of grafts in each group at risk in parenthesis. Standard errors greater than 10.0% are not considered statistically relevant. "Pure," single-segment, composite or sequential grafts of one type of conduit: vein (including greater saphenous vein, LSV, or arm vein) or PTFE only.

Table IV. Reasons for a failing or failed infrapopliteal bypass using ALSV or prosthetic graft (96 total)

Time = 0 to 1 month (17 grafts occluded or revised)
- 5 Poor run-off
- 4 Technical (2: missed valve, 2: steal through arteriovenous fistula)
- 4 Small diameter vein
- 2 Low cardiac-output
- 2 Unknown

Time < 1 month (54 grafts occluded or revised)
- 37 Intimal hyperplasia (at anastomosis or in vein graft)*
- 6 Progression of distal arterial disease
- 3 Infection
- 1 Small vein
- 7 Unknown

*Although gross findings of intimal hyperplasia were identified at the site of stenosis when these grafts were directly explored at those sites, microscopic studies were not performed to confirm this finding.

tween translocated or reversed ALSV grafts. Reasons for a failed or failing graft are listed in Table IV.

The average operative time was significantly longer for ALSV bypass procedures (6.2 hours; range, 3.5 to 10 hours) compared with PTFE bypass procedures (4.9 hours; range, 2 to 8 hours; $p = 0.003$). However, the average operative time for patients who underwent single-length PTFE bypass procedures without attempted revision of previous grafts and without placement of an adjunctive fistula was 2.5 hours, and included the eight patients who had PTFE grafts placed because they were considered to be at too high a risk to undergo a bypass procedure using ALSV. The average operative time for patients who underwent single-length arm vein bypass procedures without attempted revision of previous grafts was 4.0 hours. An average of 0.5 hours was spent for both the completion arteriogram and DU when these studies were performed, and these tests were included in the operative time.

The average length of hospitalization for patients who underwent ALSV bypass procedures was significantly shorter (7.5 days; range, 2 to 17 days) compared with those who underwent PTFE bypass procedures (10.3 days; range, 1 to 29 days; $p = 0.04$). We could not identify reasons for the longer length of hospital stay for patients with PTFE grafts. Three patients with prosthetic bypass grafts developed graft infections during follow-up; none of the patients with vein bypass grafts did. There were no significant complications associated with the 45 ALSVs harvested. Although we did not specifically evaluate incisional pain, most patients with a posterior leg incision for LSV harvesting mentioned that site as a particular annoyance that inhibited early ambulation, whereas arm vein incisions were generally well tolerated.

DISCUSSION

Revascularization of a chronically ischemic lower extremity that requires a bypass graft to an infrapopliteal artery when the GSV has previously been used or when it is inadequate is one of the most challenging clinical problems that vascular surgeons face. Similar to other tertiary care hospitals that specialize in difficult lower extremity revascularizations, more than one third of infrapopliteal bypass procedures

performed at our medical center during the past 5 years (96 of 266; 36%) were constructed using ALSV or PTFE grafts because GSV was not usable. The primary patency rates of infrapopliteal arterial bypass grafts using these ectopic veins in the current series were disappointing compared with a few other centers' reports.[3-8] These results occurred despite our best efforts to ensure a technically adequate operation, including *routine* use of preoperative vein mapping with DU and intraoperative completion arteriography, and *liberal* use of angioscopy for arm vein conduits, intraoperative completion DU for ALSV bypass grafts, adjunctive arteriovenous fistulas and vein cuffs or patches for prosthetic bypass grafts, and lifelong anticoagulation therapy in the majority of patients in both groups. All four vascular surgeons who performed these tibial bypass procedures were trained at accredited vascular fellowship programs that specialized in difficult, redo distal lower extremity revascularization procedures.

Patency rates of infrapopliteal prosthetic bypass grafts in our series compared less favorably with a few other series' reports but equally well as some others.[1,2,11-13] Flinn et al.[2] reported a 5-year primary patency rate of almost 50% for infrapopliteal prosthetic bypass grafts when patients received chronic anticoagulation therapy, whereas the 2-year patency rate in the current series was only 17%. However, the better patency rates in Flinn's series were achieved only in patients who were documented to remain adequately anticoagulated using serial blood tests. In our series, this was left to the primary care physician. More than half of the prosthetic bypass grafts in our series had adjunctive arteriovenous fistulas or vein cuffs or patches placed at the distal anastomosis, which are techniques that have been reported to improve prosthetic bypass patency rates.[11-13,17] Obviously, our results cannot be used to support these claims. The results in our series are more in line with the multicenter, prospective randomized trial reported by Veith et al.,[1] which documented primary patency rates for prosthetic infrapopliteal bypass grafts of only 12% at 4 years. Therefore, the poor patency rates of infrapopliteal tibial bypass grafts in the current series are in line with this classic study.

Although others reported 3- to 5-year patency rates approximating 40% to 50% for arm vein and LSV lower extremity arterial bypass grafts, we observed a 2-year primary patency rate of only 19%.[3-8] Others have also documented inferior results with arm vein compared with GSV grafts.[9] Our 2-year assisted primary patency rate for single-length arm veins (55.0%) was more in line with these other published results, but the small numbers of grafts in this subgroup probably prevented any statistically significant conclusions. We believe our poorer overall ALSV results may also be accounted for by several significant factors that other reports did not address. First, other series of arm and LSV grafts included bypass grafts to the popliteal artery in one quarter to one third of cases, as opposed to only infrapopliteal bypass grafts in our series.[3-8] Second, more than one third of the ALSV bypass grafts in our series were the distal segment of a sequential or composite graft, whereas several other series included only single-segment ALSVs. Sequential and composite bypass grafts may yield lower patency rates than single-segment bypass grafts because of an increased chance of graft kinking or twisting and the need for additional anastomoses with a greater likelihood of technical error and development of intimal hyperplasia,[18,19] although a previous report from our institution documented acceptable patency rates for sequential bypass grafts.[20] Third, we maintained a very aggressive attitude regarding arterial graft surveillance to prevent graft thrombosis and may have intervened earlier for some failing grafts than other centers. This strategy may have led to our lower primary patency rates but ideally should have led to equal or improved assisted primary patency rates. This is suggested in the current series but not proven, probably because of the small number of certain subsets of ALSVs. Fourth, approximately one third of ALSVs in our series (14 of 45) measured less than 4.0 mm in diameter in at least one segment of the graft (Table I). This suggests that our poorer results are likely related in large part to a difficult case mix. Other previously mentioned factors may have had a negative impacted, specifically on the patency rates of ALSV bypass grafts compared with prosthetic grafts in our series, although the effect of these factors on patency rates has never clearly been proven.

The average time required to perform ALSV bypass procedures was significantly longer than the time required to perform PTFE bypass procedures, although this difference may not be clinically relevant. The duration of the operation for both ALSV and PTFE bypass procedures was extensive because of several factors: (1) in most cases an aggressive attempt was made to salvage the original graft; (2) the majority of patients (76 of 96; 79%) had undergone one or more previous revascularization procedures, which made reexploration of previously scarred tissues difficult and time-consuming; (3) the proximal graft of a sequential or composite bypass graft was frequently performed at the same operation

as placement of the distal ALSV or PTFE graft to an infrapopliteal artery; (4) harvesting ALSVs is probably more time-consuming than harvesting GSVs because of the increased friability of these ectopic veins and relative inaccessibility of the LSV unless the patient is repositioned; and (5) approximately half of the PTFE grafts had distal anastomotic arteriovenous fistulas, which frequently involve friable tibial veins with multiple small branches. This adjunctive technique adds a significant length of time to the operation.

Limbs were salvaged in approximately three quarters of these challenging patients after an average follow-up of 2 years. However, it should be noted that new bypass grafts were frequently required, especially in the prosthetic graft group, to achieve limb salvage after the ALSV or PTFE graft occluded.

We found that ALSV and PTFE bypass grafts to infrapopliteal arteries yielded low patency rates compared with a few previously reported results, although the 2-year assisted primary patency rate of 55% for single-length arm veins was in line with the results in other series. When GSV is not available in either leg, we believe that there are several factors that favor the construction of arm vein grafts instead of PTFE grafts for infrapopliteal bypass procedures. Only slightly longer operative times, decreased length of hospital stay, possible decreased incidence of graft infection, and the trend toward higher assisted primary patency rates of arm vein grafts, despite the fact that ALSVs were more commonly anastomosed to pedal arteries, less likely to be treated with anticoagulation mediation, and had higher runoff resistance values, make it worth the extra effort to use good-quality arm veins as the first choice for infrapopliteal bypass grafts instead of using PTFE grafts, especially in good-risk patients in whom long-term survival is expected.

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DISCUSSION

Dr. R. Clement Darling III (Albany, N.Y.). Dr. Calligaro and his group from Pennsylvania Hospital have presented their data on 96 infrapopliteal arterial reconstructions in 72 patients using 45 arm and lesser saphenous veins and compared them with 51 prosthetic infrapopliteal reconstructions. The 2-year primary patency rates were 24% and 15%, respectively, with an assisted primary patency rate of 46% for arm veins, 23% for lesser saphenous veins, and 26% for PTFE. The limb salvage rates in these patients were 76% and 71%, respectively. Unfortunately, the reported patency rates in this series are less than those reported in the literature with spliced veins when used for secondary and tertiary reconstructions, with a primary patency rate of approximately 45%. The difference in the results may be a result of certain factors, and I have a few questions for Dr. Calligaro.

First, do you think that the reliance on previous reconstructions for inflow, such as you did for composite reconstructions, limited the patency rate of these grafts?

Second, how did you evaluate your inflow? Because you were using single segments of vein in many cases, such as lesser saphenous vein, which classically only measures about 30 cm in length, do you think you used a disadvantaged inflow and outflow and that this could be a reason for your decreased patency results?

Also, you mentioned that early in your experience you used a 2.8-mm angioscope liberally, which may have impacted negatively by causing endothelial trauma. I see that you now have changed to using a smaller scope. However, that begs the question. When a lesion was recognized in the vein as you did your angioscopy, did you perform venovenostomies and excise the segment of questionable vein or did you accept a compromised segment of that venous conduit? In other words, did your angioscopic data help you guide your therapy, and did it change any of your operations?

Also, do you think that by harvesting lesser saphenous veins prone and then repreparing and draping the patient that the prolonged warm ischemia time to this mesenchymal tissue had a negative impact on your results?

As noted in your paper, we, as well as others, have used a single-incision medial approach to the lesser saphenous vein to minimize this warm ischemia time, and I was wondering whether you could tell whether maybe this approach might have helped?

Also, if you felt that composite grafts did have a negative impact on your results, do you think it might have been better to opt for a new bypass graft primarily and avoid the prior operative fields, as this may save operative time and avoid any prior disease in the original conduit?

Lastly, you noted that the average length of hospitalization for the venous reconstruction patients were significantly shorter compared with the PTFE bypass patients. Could you elucidate on the reasons for this?

Dr. Keith D. Calligaro. In answer to the first question, our reliance on previous reconstructions possibly led to a lower patency rate. We always obtain preoperative arteriograms to document that those inflow grafts were of good quality without any stenoses.

In terms of using single segments of vein, the same answer applies. The arteriograms documented that our inflow seemed acceptable.

In terms of the angioscope, we are using a smaller scope now, which theoretically causes less intimal damage. When a lesion was identified by angioscopy, we would aggressively try to repair that lesion. The most common lesion to find when you're using arm vein is a fibrotic or diseased valve, probably from a previous venipuncture. We would cut down on that segment, make a venotomy, excise it, and put a vein patch on it, or excise the segment and approximate the two ends or place an interposition graft.

The prolonged warm ischemia time is an excellent point. When we excise the lesser saphenous vein and then reposition the patient, the vein was stored in an iced, heparinized saline solution during that time.

In terms of opting for an entirely new bypass graft when we had to splice these smaller segments together, the bottom line was that we couldn't opt for a new bypass graft unless we were going to use a prosthetic graft. And as I said, we've been trying to use any ectopic vein that we could.

The average length of hospitalization was shorter for the patients who underwent vein bypass procedures. That result may be related to the fact that when you perform a tibial bypass procedure with an arm vein, you're only making two small incisions in the leg and then the graft can be tunneled subcutaneously. The patients can get up and walk the next day or 2 days later, and that may be why they go home a little bit earlier. But the other side of the coin is that the prosthetic graft patients were probably a little sicker in terms of their heart.

Dr. Ibrahim M. Ibrahim (Englewood, N.J.). As most of you know, we use umbilical vein graft when saphenous vein is either not usable or not available. On occasion we will use an arm vein, but in our experience use of the umbilical vein as a conduit has worked equally well when compared with cephalic and basilic veins. This has been substantiated by others, that is, the patency rate of arm veins falls short of that which is attainable with saphenous vein, and their patency rates are comparable with ours when umbilical vein is used.

Dr. Calligaro, you used the distal arteriovenous fistula in 40% of the PTFE grafts. How do you decide when and when not to use this? Do you notice differential patency rates when comparing grafts that have distal arteriovenous fistulas with grafts that do not?

Dr. Calligaro. Thank you, Dr. Ibrahim. We appreciate the work that you and Dr. Dardik have done using the umbilical vein and the fistulas.

We tended to use a fistula for some of the smaller arteries that had a more disadvantaged outflow, and of

course the adjacent tibial vein had to be adequate to use. If the tibial veins were too small, then we would not construct a fistula, obviously.

Dr. Enrico Ascher (Brooklyn, N.Y.). I want to commend you on a very honest and clearly presented paper. I have a couple of questions for you. First, I would like to know how you explain such a large difference between your limb salvage rates and patency rates? That's not what you usually see.

Second, do you have any data, although I know the numbers are small, between the patients with PTFE grafts with and without fistulas? I might add that this is not really only an adjunctive vein we're used to using, but also an interposition vein that has a potential advantage of enlarging the anastomosis and providing some compliance match, although this has not been proven. But I'm just curious to know, because I think you lumped a lot of techniques together with few patients, and we may end up with the wrong conclusions.

Dr. Calligaro. The difference in limb salvage and patency rates was somewhat surprising. When we analyzed the data closer, the difference between the prosthetic graft secondary patency rate and the limb salvage rate was about 15%, which is about what every series has shown. For the vein grafts there was a larger difference. Those patients needed repeated operations to maintain limb salvage.

In terms of the fistulas of the prosthetic grafts, about half had fistulas. We found a trend favoring the fistulas. But again it was not randomized.

Dr. Robert W. Hobson II (Newark, N.J.). I enjoyed your paper very much. Last year at this Society, as you know, we presented some data on the use of a Miller cuff with mandatory PTFE and reported patency rates at 18 to 24 months that are about double for femoropopliteal and tibial grafts as you have reported. I am wondering, based on your current results, what your posture will be next week when you encounter one of these patients and have to use a PTFE graft. Is some adjunctive measure necessary? If so, what would your choice be between arteriovenous fistula and cuff, either Miller or Taylor?

Dr. Calligaro. We tried to determine why the results were not as good as in some other series. The patients with prosthetic grafts all had anticoagulation therapy. Until a randomized study is performed, I don't think we're going to have the answer as to whether fistulas, patches, or cuffs are better than nothing.

In answer to your specific question, Dr. Hobson, we will either place a fistula or a patch.

Dr. Marcia A. Gutowicz (Philadelphia, Pa.). One of the things you mentioned about the hardest thing, or the most problematic circumstance, with using the arm veins is that at the valve areas there are very fibrotic areas that have to be excised and dealt with so as to prevent stricture formation. What I found in using arm veins is that they're very friable and unforgiving and cause a great deal of injury during the harvesting procedure because of the multiple tributaries. Historically, there is a paper that describes creating a radiocephalic fistula before operation in patients so that the vein itself becomes thickened and more durable. If you have time 3 or 4 weeks later, you can harvest the cephalic vein and use that for your bypass graft. I was wondering whether you ever considered that or had any thoughts on that?

My second question is whether in any cases you used the arm veins in a nonreversed, valveless situation with the valvulotome or the valve cutter. Were there any problems with additional trauma to these very thin, friable veins using the valve cutter or valvulotome?

Dr. Calligaro. Yes, we are aware of that paper in which an arteriovenous fistula was constructed in the arm to enlarge and thicken the walls of the arm vein. Although that concept is very appealing, there are very few patients that we see who can wait a month to 6 weeks for surgery. I guess there is an occasional patient with rest pain or a very superficial ulcer who could wait for 6 weeks or so to undergo the operation, but the vast majority of our patients needed revascularization within a week, so I don't know how many times we could apply that strategy.

In answer to your second question, I'm not quite sure I understood it. As I mentioned, almost always the arm veins are placed in a translocated fashion where the valves were cut with the use of an angioscope. Occasionally, we would place them reversed if the wrist diameter was the same as in the shoulder, but that was not often.

Dr. Frank T. Padberg (East Orange, N.J.). A comment about the warfarin, to further amplify Dr. Hobson's comments on our presentation last year regarding vein interposition cuffs. We also used warfarin, but not in every patient as you have in this series, and found no difference in the grafts whether or not the patients had warfarin or not. There is a paucity of data regarding the use of warfarin in vein grafts, but you'll notice that the upcoming program at the SVS meeting next month has a presentation of a randomized study conducted by the Veterans Administration in which that question was asked. I wonder whether you're still going to continue doing this in the future and how you control for the level of anticoagulation in these patients.

Dr. Calligaro. That's an excellent point. We routinely give our patients who have a prosthetic infrapopliteal bypass heparin at a dose of 500 units per hour in the immediate perioperative period. We do that to avoid the high incidence of wound hematomas. We're going to continue to do this until there is a randomized study that shows that anticoagulation is not any better. We're trying to do everything we can to keep those grafts open. We then give those patients warfarin beginning the day after surgery.

But the point you're getting at is a very good one. We do not manage the warfarin levels. We have our primary care physicians or the internists manage our warfarin with strict instructions to keep the international normalized ratio at twice the control level. Despite that, very fre-

quently the international normalized ratio levels become subtherapeutic. Whether that really makes a difference, I'm not sure. But the Northwestern study clearly showed that if patients are not fully anticoagulated, they had a higher incidence of graft thrombosis.

Dr. Richard M. Green (Rochester, N.Y.). The best thing I saw in your slide was that your patients are in the hospital for this long, because, as you know, you are responsible for this group going around the country telling us how quickly we have to send our patients home. So can we take this home to them and say it's okay to be in the hospital 10 days?

Dr. Calligaro. We still tried to get these patients out of the hospital as soon as we could. When you have a patient who needs their third or fourth revascularization procedure, obviously they're going to be in the hospital longer than the first time you perform a femoropopliteal above-knee bypass procedure. But yes, Dr. Green, it's fine with me to tell your patients that it is okay to be in the hospital 10 days.